ORIGINAL RESEARCH ARTICLE

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SimCP: A Simulation Platform to Predict Gait Performance Following Orthopedic Intervention in Children With Cerebral Palsy

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Gait deficits in cerebral palsy (CP) are often treated with a single-event multi-level surgery (SEMLS). Selecting the treatment options (combination of bony and soft tissue corrections) for a specific patient is a complex endeavor and very often treatment outcome is not satisfying. A deterioration in 22.8% of the parameters describing gait performance has been reported and there is need for additional surgery in 11% of the patients. Computational simulations based on musculoskeletal models that allow clinicians to test the effects of different treatment options before surgery have the potential to drastically improve treatment outcome. However, to date, no such simulation and modeling method is available. Two important challenges are the development of methods to include patient-specific neuromechanical impairments into the models and to simulate the effect of different surgical procedures on post-operative gait performance. Therefore, we developed the SimCP framework that allows the evaluation of the effect of different simulated surgeries on gait performance of a specific patient and includes a graphical user interface (GUI) that enables performing virtual surgery on the models. We demonstrated the potential of our framework for two case studies. Models reflecting the patient-specific musculoskeletal geometry and muscle properties are generated based solely on data collected before the treatment. The patient's motor control is described based on muscle synergies derived from pre-operative EMG. The GUI is then used to modify the musculoskeletal properties according to the surgical plan. Since SEMLS does not affect motor control, the same motor control model is used to define gait performance pre- and post-operative. We use the capability gap (CG), i.e., the difference between the joint moments needed to perform healthy walking and the joint moments the personalized model can generate, to quantify gait performance. In both cases, the CG was smaller post- then pre-operative and this was in accordance with the measured change in gait kinematics after treatment.

Keywords: cerebral palsy, muscle synergies, single event multilevel surgery, orthopedic interventions, capability gap, subject specific model

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